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Adult Age Differences in Frequency Estimations of Happy and Angry Faces

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Abstract

With increasing age, the ratio of gains to losses becomes more negative, which is reflected in expectations that positive events occur with a high likelihood in young adulthood, whereas negative events occur with a high likelihood in old age. Little is known about expectations of *social* events. Given that younger adults are motivated to establish new social relations, they should be vigilant towards signals of opportunities for socializing, such as smiling faces. Older adults, who are particularly motivated to avoid negative encounters, should be vigilant towards negative social signals, such as angry faces. Thus, younger adults should overestimate the occurrence of positive social signals, whereas older adults should overestimate the occurrence of negative social signals. Two studies (Study 1: $n = 91$ younger and $n = 89$ older adults, Study 2: $n = 50$ younger and $n = 50$ older adults) partly supported these hypotheses using frequency estimates of happy and angry faces. Although both younger and older adults overestimated the frequency of angry compared to happy faces, the difference was significantly more pronounced for older adults.

Keywords: frequency estimation, emotional faces, adult age differences

Adult Age Differences in Frequency Estimations of Happy and Angry Faces

Across adulthood, the balance of developmental gains (i.e., perceived desirable changes) and losses (i.e., perceived undesirable changes) changes from a predominance of gains in younger age groups to increasingly more losses in old age (Baltes, 1997). This development is reflected in expectations that gains and positive events occur with a high likelihood in young adulthood, whereas losses and negative events occur with a high likelihood in old age (Heckhausen, Dixon, & Baltes, 1989). For example, beginning around age 65, older adults expect the future to be less satisfying than the present, whereas younger age groups expect future gains in life satisfaction (Lachman, Röcke, Rosnick, & Ryff, 2008). Less is known about expectations that people of different ages have in the social domain. One exception is a study by Mustafić and Freund (2012) that demonstrated that, different to younger and middle-aged adults, older adults expect their social relations to decline over the next ten years. However, in contrast to the findings of age-related decline in the domains of physiological, cognitive, and health-related functioning (e.g., Kaiser, 2009; Lachman, 2006), there is substantial evidence that social relations do not suffer in older adulthood (Carstensen, 1993). For instance, older adults report a greater number of positive and a smaller number of negative social events than younger age groups (Birditt, Fingerman, & Almeida, 2005). Moreover, older adults seem to be particularly motivated to maintain positive social relations and avoid negative ones (Carstensen, 1993).

Charles (2010) posits that negative social encounters elicit higher levels of sustained emotional arousal in older than in younger adults. According to Charles, this is the reason for older adults' higher motivation to avoid or reduce exposure to negative social events. Research on social motivation provides evidence that people who want to avoid negative social events generally expect others to behave in a negative way more readily than people who are less concerned about negative social events (Mehrabian, 1994; Strachman & Gable, 2006).

Consequently, being avoidance motivated is associated with a higher sensitivity to negative social stimuli such as angry faces (Nikitin & Freund, 2011). Given that older adults are particularly motivated to avoid negative social encounters, older adults should be particularly vigilant towards negative social stimuli and, because of that, overestimate the frequency with which they occur.

In contrast, people who want to approach positive social events generally expect others to behave in a positive way more readily than people who are less motivated to approach positive social events (Mehrabian, 1994). Developmental tasks in young adulthood are associated with establishing new social relations, such as finding a romantic partner, building social networks at the workplace, and building new friendships after moving away from home (e.g., Arnett, 2000; Eccles, Templeton, Barber, & Stone, 2003). Thus, younger adults should be particularly motivated to approach new social partners. Being approach motivated, in turn, is associated with a higher sensitivity to positive social stimuli (Gomez & Gomez, 2002). If younger adults are primarily motivated to establish positive social encounters, they should be vigilant towards positive social signals (e.g., smiling faces) and overestimate the frequency with which they occur.

An alternative hypothesis can be derived based on the age-related positivity effect (e.g., Carstensen & Mikels, 2005). According to socioemotional selectivity theory (SST; Carstensen, Isaacowitz, & Charles, 1999), older adults have a stronger chronically activated goal to feel good than younger adults. This goal is reflected in enhanced processing of positive over negative information in older compared to younger adulthood, i.e., the positivity effect. A number of studies have found evidence for the positivity effect (for a meta-analysis, see Murphy & Isaacowitz, 2008). Based on the positivity effect, older adults should overestimate the frequency of positive social stimuli and underestimate the frequency of negative social stimuli to a higher degree than younger adults. The current studies tested these alternative hypotheses. To that end, we used frequency estimations of rapidly presented positive (i.e., happy faces) and negative social stimuli (i.e., angry faces).

The Relationship between Expectations and Frequency Estimates

Frequency estimates involve estimating how many instances there are in a class (e.g., “How many angry people were in the group?”) (Hasher & Zacks, 1984). Frequency estimates are typically performed in a heuristic manner and do not entail an exhaustive search of memory (Garcia-Marques, Hamilton, & Maddox, 2002). In fact, people are able to produce reasonable frequency estimates of given categories without being able to retrieve any specific exemplars (Beyth-Marom & Fischoff, 1977). One of the models of frequency estimations is by Tversky and Kahneman (1974) and proposes that estimations are made on the basis of the ease or fluency of the retrieval of specific stimuli or classes of stimuli. Because expectancy-congruent items are more strongly associated with the target category than incongruent items, they are more easily assessed during retrieval, thereby leading to higher frequency estimates. In line with these assumptions, Garcia-Marques et al. (2002) found in several studies on frequency estimations an expectancy-based overestimation of congruent items. This effect was highly robust and independent of cognitive load. Thus, frequency estimates seem to be positively correlated with the expectations people hold. Or, in other words, “social expectancies and memory are two sides of the same cognitive coin” because “expectancies capitalize on knowledge accumulated in memory to ease the cognitive load of everyday information processing” (Garcia-Marques et al., 2002, p. 193).

Age Differences in Frequency Estimates

Although age differences in frequency estimates have been investigated for decades (Hasher & Zacks, 1984; Spaniol & Bayen, 2005; Wiggs, Martin, & Howard, 1994), there is a lack of studies using social-emotional stimuli such as facial expressions. With respect to frequency estimates of neutral stimuli, Hasher and Zacks (1979) suggested that processing the frequency of occurrence of events develops early and remains intact into old age. This should be the case because, as previously discussed, frequency estimates involve automatic processes that do not change with age. However, the empirical evidence on age invariance in frequency estimates is mixed. Although there exist studies supporting the age invariance of frequency-of-occurrence judgments (Attig & Hasher, 1980; Hasher & Zacks, 1979; Kausler & Puckett, 1980; Sanders, Wise, Liddle, & Murphy, 1990), others suggest that older adults perform poorer on frequency judgments than younger adults (Di Pellegrino, Nichelli, & Faglioni, 1988; Freund & Witte, 1986; Kausler, Salthouse, & Saults, 1987; Mutter & Goedert, 1997; Wiggs et al., 1994). In these studies, older adults generally tend to underestimate the objective item frequencies to a greater degree than younger adults. Spaniol and Bayen (2005) explain these results with an age-related reduction in the encoding of information. In fact, Spaniol and Bayen demonstrated that equating younger and older adults on encoding (by manipulating the presentation time) eliminated or reduced age differences in frequency estimations.

In the present studies, we tested age-related differences in frequency estimations of happy and angry faces. Happy faces are seen as positive social signals (signaling positive social interaction), whereas angry faces are seen as negative social signals (signaling negative social interaction; Ekman & Oster, 1979). Based on the assumption that younger adults expect a higher ratio of positive to negative social events and older adults a higher ratio of negative to positive social events, we hypothesize that younger adults will overestimate the frequency of happy compared to angry faces and, vice versa, older adults will overestimate the frequency of angry compared to happy faces. An alternative hypothesis derived from the age-related positivity effect leads to the opposite prediction.

Based on the findings by Spaniol and Bayen (2005), we used relatively short presentation times to equate the encoding process and, thereby, eliminate the main effect of age on frequency estimations. Additionally, short presentation times should foster heuristic processing of the presented information, enabling people's expectancies to be influential while making frequency estimations (Gigerenzer & Goldstein, 1996).

Study 1

Method

Study 1 used a 2 × 2 mixed design with valence of the facial stimuli (happy vs. angry faces) as a within-participant variable and age of participants (younger vs. older adults) as a between-participants variable.

Participants. Participants were recruited via clubs, flyers, and advertisements in mailing lists. The original sample consisted of n = 92 younger and n = 92 older adults. One younger and three older adults did not finish the study due to motivational or technical problems. The final sample consisted of n = 91 younger (71.4% female, age M = 23.61, SD = 3.1, range: 19 to 35 years) and n = 89 older adults (66.3% female, age M = 71.76, SD = 6.08, range: 60 to 93 years). Approximately half of the young adults was single (54.9%) and 42.9% were married or in a steady relationship. From the older group, 13% were single, 51.4% married or in a steady relationship, 10.9% widowed, and 17.4% divorced. Regarding education, one young participants reported having finished obligatory school, 73.6% finished high school, and 20.9% university. Two persons reported some other kind of education. Three older adults reported having finished obligatory school, 44.6% finished apprenticeship or upper professional training, 14.1% high school, 21.8% university, and 8.7% some other kind of education. Two young and seven older persons did not provide socio-demographical information.

Before the start of the study, participants gave written informed consent for participation. After participation, they were fully debriefed and received either additional course credit or 20 CHF as a means of compensation.

Materials and equipment. The stimuli were selected from the Lifespan Database of Adult Emotional Facial Stimuli (Ebner, Riediger, & Lindenberger, 2010) with photographs of 171 models (29 younger men, 29 younger women; 29 middle-aged men, 27 middle-aged women; 28 older men, 29 older women; the presentation of these different age- and gender-categories was randomized). The photographs were validated for young, middle-aged, and older adults (Ebner et al., 2010). Each model expressed three posed, emotional states (happiness, anger, neutral). Each photograph was 2.6'' high and 2.1'' wide. To obtain the highest possible uniformity, all photographs were gray-scaled. Stimuli were presented on a 17'' computer screen. We used the software MediaLab and DirectRT (Jarvis, 2004) for stimulus presentation, timing, and data collection.

Visual acuity and contrast. Visual acuity and contrast were measured using the Freiburg Visual Acuity and Contrast Test (Bach, 1996, 2007). Higher values in visual acuity (Landort-c variance) indicate better visual acuity, lower values in contrast test (Weber percentage) indicate better contrast ability. Younger adults ($M = 1.5$, $SD = 0.31$) had a significantly better visual acuity than older adults ($M = 0.82$, $SD = 0.33$), $t(178) = 14.27$, $p < .001$, $d = 2.14$, and younger adults ($M = 1.29$, $SD = 0.39$) also had a higher contrast ability than older adults ($M = 3.81$, $SD = 10.78$), $t(178) = -2.22$, $p = .03$, $d = 0.33$. To test if visual acuity and contrast affected frequency estimates, we ran hierarchical regression analyses with age, visual acuity, and contrast in the first and their interactions in the second step as predictors of frequency estimates. Neither visual acuity, nor contrast, nor their interactions with age predicted frequency estimates of happy or angry faces (all *p*s > .10). Thus, there was no need to control for visual acuity and contrast in the following analyses.

Procedure. Prior to coming to the laboratory session, participants completed at home an online self-report questionnaire assessing socio-demographic variables and scales that are not relevant for the current study. In the laboratory session, we first assessed visual acuity and then administered the frequency-estimation task. An experimental trial started with the presentation of a blank screen and was followed by a rapid succession of 90 photographs depicting happy, angry, and neutral facial expressions, each presented in the center of the screen for 150 ms. After each trial, participants estimated how many happy and angry faces they believed they had seen by typing the relative frequency (in percent) in blank boxes (upper box for happy, lower box for angry faces). Participants could start with either of the two categories. After they estimated the two categories, the computer automatically completed the third category (neutral faces) so that the sum added up to 100 percent. Participants could change the estimates as often as they wanted to before proceeding to the next trial. The order of the presentation of the facial expressions within a trial and the order of trials were randomized. The number of the emotional (happy or angry) faces varied between zero and 70 in seven-point steps (0, 7, 14, 21, etc.) resulting in a total of 11 trials. The number of neutral faces was held constant at 20.[1] Neutral faces were used as a control category and were not analyzed (note that the difference regarding the estimation of neutral faces is a direct result of the estimations of positive and negative faces).

Data-analytical strategy. Analyses were performed on three measures (for a similar procedure, see Brown, 1995; Mutter & Goedert, 1997): (1) the degree of overall error in the participant's estimates provided by the unsigned deviation of estimated frequency from presented frequency (i.e., |Estimated – Presented Frequency|); (2) the degree of over- or underestimation provided by the signed deviation of estimated frequency from presented frequency (i.e., Estimated – Presented Frequency); and (3) the dependency of participant's estimates on differences in presentation frequency (i.e., relative accuracy), provided by the slope of a multilevel analysis with presented frequency on Level 1, participant on Level 2, and facial expression and age group on Level 3 as predictors of estimated frequency.

Results

Overall error. To test the effect of age and facial expression on the degree of overall error in the participants' estimates, we conducted a repeated-measures ANOVA with age (young vs. old) as a between-participants factor and facial expression (happy vs. angry) as a within-participants factor (see Figure 1, upper graph). The results revealed a main effect of age ($F[1, 178] = 26.42$, $p < .001$, $\eta_p^2 = .13$) and a main effect of facial expression ($F[1, 178] = 78.16$, $p < .001$, $\eta_p^2 = .31$). All participants made more errors when estimating angry ($M = 5.48$, $SD = 13.45$) than happy faces ($M = 3.48$, $SD = 11.0$) and older adults ($M = 13.83$, $SD = 4.94$) made more errors in their estimations than younger adults did ($M = 10.65$, $SD = 3.2$). There was no Age × Facial Expression effect, $p = .39$.

Under- and overestimation. The second measure tested if this overall error was explained by under- or overestimation. Again, we conducted a repeated-measures ANOVA with age (young vs. old) as a between-participants factor and facial expression (happy vs. angry) as a within-participants factor. The results revealed a main effect of facial expression ($F[1, 178] = 46.9$, $p < .001$, $\eta_p^2 = .21$) and a main effect of age ($F[1, 178] = 3.78$, $p = .05$, $\eta_p^2 = .02$). These main effects were qualified by an Age × Facial Expression interaction effect, $F(1, 178) = 4.33$, $p = .04$, $\eta_p^2 = .02$. As can be seen in Figure 1 (middle graph), both younger ($t[90] = 3.8$, $p = .001$, $d = 0.80$) and older adults ($t[88] = 7.11$, $p < .001$, $d = 1.52$) overestimated more strongly the frequency of angry than of happy faces. However, older adults underestimated happy faces more than younger adults, $t(178) = 3.78$, $p = .001$, $d = 0.57$ (in fact, younger adults' estimates of happy faces did not significantly differ from zero, $p = .31$), but younger and older adults did not significantly differ in their overestimation of angry faces, $p = .93$. Additionally, the difference between older adults' estimation of angry compared to happy faces was significantly larger than the difference between younger adults' estimation in the two conditions, $t(178) = 2.08$, $p = .04$, $d = 0.31$, suggesting that older adults estimated relatively more angry than happy faces compared to younger adults.

Relative accuracy. Finally, the relative accuracy tested the over- and underestimation as a function of the presented frequency. As reported in the data-analytical strategy, we ran a multilevel analysis with presented frequency, valence of the facial expression (angry = 0, happy = 1) and age (young = 0, old = 1) as predictors of estimated frequency (predicted slopes are presented in Figure 1, lower graph). In addition to a main effect of presentation frequency ($b = 0.99$, SE$b = 0.01$, $F[3'779] = 5'396$, $p < .001$), a main effect of valence ($b = -2.69$, SE$b = 0.62$, $F[3'779] = 18.9$, $p < .001$), and a main effect of age ($b = 9.66$, SE$b = 1.09$, $F[615] = 79$, $p < .001$), there was a Presentation Frequency × Age interaction ($b = -0.29$, SE$b = 0.02$, $F[3'779] = 227.26$, $p < .001$). As can be seen also from Figure 1 (lower graph), older adults' slopes were more flat than those of younger adults. In other words, older but not younger adults tended to overestimate lower frequencies and to underestimate higher frequencies. There was no significant Presentation × Age × Valence interaction ($p = .27$), suggesting that this tendency did not differ between happy and angry faces as a function of age. No other interaction was statistically significant (ps > .13).

Summary. To summarize, results of Study 1 showed that older adults' estimates are less accurate than those of younger adults and that people are generally less accurate in their estimates of angry faces than of happy faces. More importantly, younger and older adults differed in their over- and underestimation of emotional information. Although both younger and older adults overestimated angry faces, older adults also underestimated happy faces. These results support the hypothesis of higher relative salience of negative social stimuli for older compared to younger adults (and speak against the positivity effect). In contrast, there was no support for the hypothesis that younger adults overestimate happy faces. In fact, younger adults' estimates of happy faces were relatively accurate (they did not significantly differ from the presented frequency). The interaction effect of age and valence was independent of the presented frequency, although older adults showed a general tendency to the center. In other words, their estimates were more conservative or less extreme than those of younger adults.

Study 2

The aim of Study 2 was to replicate these findings. In addition, Study 2 addressed one possible shortcoming of Study 1. In Study 1, estimates of angry and happy faces were not independent (despite the inclusion of neutral faces) because they were always presented in the same task trial. Study 2 circumvents this problem by presenting angry and happy faces in separate task trials, always intermixed with neutral faces.

Method

Study 2 used a 2 × 2 mixed design with valence of the facial stimuli (happy vs. angry faces) as a within-participant variable and age of participants (younger vs. older adults) as a between-participants variable.

Participants. Participants were recruited via advertisements in mailing lists and through the participant pool of the department. The sample consisted of $n = 50$ younger adults (72% female, age $M = 25.8$, $SD = 4.61$, range: 18 to 35 years) and $n = 50$ older adults (56% female, age $M = 72$, $SD = 4.78$, range: 63 to 86 years). Sixty-two percent of the young adults were single and 38% were married or in a steady relationship. From the older group, 13% were single, 56% married or in a steady relationship, 4% widowed, and 18% divorced. Regarding education, 10%

of the young participants reported having finished obligatory school, 14% finished apprenticeship or upper professional training, 42% high school, and 34% university. Six percent of the older adults reported having finished obligatory school, 40% finished apprenticeship or upper professional training, 14% high school, and 34% university. Two older persons did not provide socio-demographical information.

Before the start of the study, participants gave written informed consent for participation. After participation, they were fully debriefed and received either additional course credit or 15 CHF as a means of compensation.

Materials and equipment. Study 2 used the same stimuli and equipment as Study 1. As in Study1 visual acuity and contrast were not systematically related to the estimation frequencies, we did not assess visual acuity and contrast in Study 2.

Procedure. After arriving in the laboratory of the department, participants completed a paper-pencil questionnaire assessing socio-demographic variables that was followed by the frequency-estimation task. Different to Study 1, the presentation of happy and angry faces was divided into two blocks. Participants were randomly assigned to either a condition starting with the happy/neutral faces block and followed by the angry/neutral faces block (n = 46) or a condition with the reversed block order (n = 54). The order of the blocks had no effect on the results. Each trial started with the presentation of a blank screen and was followed by a rapid succession of 70 photographs depicting either happy and neutral or angry and neutral facial expressions, each presented in the center of the screen for 150 ms. After each trial, participants estimated how many happy (or angry) faces they believed they had seen by typing the relative frequency (in percent) in blank boxes. After the estimation, the computer automatically completed the category of the neutral faces so that the sum added up to 100 percent. Participants could change the estimates as often as they wanted to before proceeding to the next trial. The order of the presentation of the facial expressions within a trial and the order of trials in a block were randomized. The number of the emotional (happy or angry) faces varied between zero and 70 in seven-point steps (0, 7, 14, 21, etc.) resulting in a total of 11 trials. The number of neutral faces was reversed to the number of emotional faces to sum up to 70.[2]

Data-analytical strategy. We used the same data-analytical strategy as in Study 1.

Results

Overall error. We conducted a repeated-measures ANOVA with age (young vs. old) as a between-participants factor and facial expression (happy vs. angry) as a within-participants factor. The results revealed a main effect of age ($F[1, 98] = 34.23$, $p < .001$, $\eta_p^2 = .26$) and a main effect of facial expression ($F[1, 98] = 79.03$, $p < .001$, $\eta_p^2 = .45$). These main effects were qualified by an Age × Facial Expression effect, $F(1, 98) = 17.01$, $p < .001$, $\eta_p^2 = .15$. As can be seen in Figure 2 (upper graph), both younger ($t[49] = 5.14$, $p < .001$, $d = 1.47$) and older adults ($t[49] = 7.35$, $p < .001$, $d = 2.1$) made more errors in their estimations of angry faces than in their estimations of happy faces. Older adults made more errors than younger adults in both happy-faces ($t[98] = 2.75$, $p = .01$, $d = 0.56$) and angry-faces condition ($t[98] = 5.76$, $p < .001$, $d = 1.16$). The difference between older adults' errors in the angry-faces compared to the happy-faces condition was significantly larger than the difference between younger adults' errors in the two conditions, $t(98) = 4.12$, $p < .001$, $d = 0.83$, suggesting that older adults made relatively more errors in the angry-faces condition than in the happy-faces condition compared to younger adults.

Under- and overestimation. Again, we conducted a repeated-measures ANOVA with age (young vs. old) as a between-participants factor and facial expression (happy vs. angry) as a within-participants factor. The results revealed a main effect of facial expression ($F[1, 98] = 37.3$, $p < .001$, $\eta_p^2 = .28$). The main effect of age was not statistically significant ($p = .11$). However, there was a significant Age × Facial Expression effect, $F(1, 98) = 11.69$, $p = .001$, $\eta_p^2 =$

.11. As can be seen in Figure 2 (middle graph), both younger ($t[49] = 3.22$, $p = .002$, $d = 0.92$) and older adults ($t[49] = 5.24$, $p < .001$, $d = 1.5$) overestimated more strongly the frequency of angry than of happy faces. However, older adults overestimated angry faces more than younger adults, $t(98) = 2.63$, $p = .01$, $d = 0.53$, but younger and older adults did not significantly differ in their overestimation of happy faces, $p = .25$ (although older adults' estimates of happy faces did not significantly differ from zero, $p = .07$, but younger adults' estimates of happy faces did, $t[49] = 5.74$, $p < .001$, $d = 1.64$). Consequently, the difference between older adults' overestimation of angry compared to happy faces was significantly larger than the difference between younger adults' overestimation in the two conditions, $t(98) = 3.42$, $p < .001$, $d = 0.69$, suggesting that older adults overestimated relatively more angry than happy faces compared to younger adults.

Relative accuracy. Finally, the relative accuracy tested the over- and underestimation as a function of the presented frequency. Again, we ran a multilevel analysis with presented frequency, valence of the facial expression (angry = 0, happy = 1), and age (young = 0, old = 1) as predictors of estimated frequency (predicted slopes are presented in Figure 2, lower graph). In addition to a main effect of presentation frequency ($b = 0.93$, SE$b = 0.15$, $F[2'099] = 3618.49$, $p < .001$), a main effect of valence ($b = -3.41$, SE$b = 0.92$, $F[2'099] = 13.95$, $p < .001$), and a main effect of age ($b = 12.80$, SE$b = 2.02$, $F[198] = 40.07$, $p < .001$), there was a Presentation Frequency × Age effect ($b = -0.20$, SE$b = 0.02$, $F[2'099] = 85.01$, $p < .001$), a Presentation Frequency × Valence effect ($b = 0.03$, SE$b = 0.02$, $F[2'099] = 4.89$, $p = .03$), and an Age × Valence effect ($b = -10.18$, SE$b = 1.29$, $F[2'099] = 62.02$, $p < .001$). These two-way interaction effects were qualified by a significant Presentation Frequency × Age × Valence effect ($b = 0.12$, SE$b = 0.02$, $F[2'099] = 28.48$, $p < .001$). As can be seen from Figure 2 (lower graph), this three-way interaction effect was particularly driven by older adults' estimates of angry faces. Older adults tended to overestimate the frequency of angry faces more, the lower the presentation frequency was.

Summary. Study 2 largely replicated the main findings of Study 1. Older adults' estimates were less accurate than those of younger adults and all participants were generally less accurate in their estimates of angry faces than of happy faces. In addition, older adults' estimates were relatively less accurate for angry than for happy faces compared to younger adults. More importantly, and in line with the results of Study 1, younger and older adults differed in their over- and underestimation of emotional information. Different to Study 1, however, this effect was mainly driven by older adults' relatively stronger overestimation of angry faces. Despite this difference, these results again support the hypothesis of higher relative salience of negative social stimuli for older compared to younger adults (and speak against the positivity effect). Again, there was no support for the hypothesis that younger adults overestimate happy faces more than older adults. Different to Study 1, the interaction effect of age and valence was not independent of the presented frequency. Older adults overestimated angry (but not happy) faces the more, the less frequently they were presented.

Discussion

Do younger and older adults differ in their expectations – and resulting estimations – of encountering positive or negative social stimuli? Based on the age-related differences in the gain-loss ratio (Baltes, 1997), we hypothesized a stronger overestimation of happy faces by younger compared to older adults and a stronger overestimation of angry faces by older compared to younger adults. An alternative hypothesis was derived from the age-related positivity effect (Carstensen & Mikels, 2005). The results did not support the positivity-effect hypothesis and provided partial support for the gain-loss hypothesis. Overall, the current studies provide three main insights on the role of age for the estimation of emotional material. First, both younger and older adults overestimated angry faces over happy faces. Second, older adults showed a stronger overestimation of angry compared to happy faces than younger adults. Third, older adults tended to overestimate low presentation frequencies and underestimate high presentation frequencies. We will address each of these points in the following discussion.

Overestimation of angry faces. Both younger and older adults were less accurate in their estimations of angry faces than of happy faces. This overall error was qualified by stronger overestimation of angry over happy faces. This finding is in line with previous research on the negativity dominance (Rozin & Royzman, 2001). There is substantial empirical evidence that people are generally vigilant to angry faces (for a review, see Vuilleumier, 2002) and previous studies found no age-related differences in the detection of angry faces (Mather & Knight, 2006). In general, negative information attracts more processing resources than positive or neutral information, irrespective of age (Grühn, Smith, & Baltes, 2005). Some authors argue that, whereas the processing of negative information is often crucial for the organism, the processing of positive information is much less so (Rozin & Royzman, 2001). The overestimation of angry faces in the current studies might reflect this fact.

An alternative explanation of the stronger overestimation of angry compared to happy faces is methodological in nature. Most of the happy faces in the FACES database feature open mouths, whereas the mouths are closed in the angry and neutral facial expressions. Thus, happy faces differ from angry and neutral faces in one important visual feature. The greater visual similarity of angry and neutral faces might lead to an overestimation of angry faces as they might be confused more easily with neutral faces. Note, that this cannot explain why younger and older adults differed in their estimations of happy faces (as found in Study 1). In addition, visual acuity and contrast did not affect the estimates. However, future research is needed to replicate the present findings with different social stimuli.

Age × Valence interaction. In addition to the main effect of facial expression, estimates of the frequency of happy and angry faces also differed as a function of age group. In both studies, older adults showed a relatively stronger overestimation of angry compared to happy faces than younger adults. Given that expectation is associated with frequency estimations (Spaniol, Voss, Bowen, & Grady, 2011), this latter finding provides indirect support for the assumption that older adults expect to encounter relatively more negative than positive social events than younger adults. This finding is inconsistent with the age-related positivity effect reported by Carstensen and colleagues (e.g., Carstensen & Mikels, 2005) and suggests that the positivity effect occurs under some but not under all conditions (Depping & Freund, 2013; Mather & Knight, 2005). The current studies add to exploring the boundaries of the positivity effect by demonstrating that frequency estimations of social emotional stimuli are not positively biased in older adulthood. To the contrary, the current studies speak in favor of a negativity effect in both age groups.

One possible explanation of this negativity effect is the automaticity of frequency estimations, at least during the encoding process (Hasher & Zacks, 1984; Sanders et al., 1990; Wiggs et al., 1994). Mather and Knight (2005) demonstrated that automatic encoding processes do not show a positivity effect in older adulthood but instead a negativity effect. Mather and Knight (2005, Study 3) found that when older adults' attention was distracted during the encoding process, compared to younger adults they recalled significantly fewer positive than negative information. The authors interpret these results with "ironic processes" (Wegner, 1994): Older adults' chronic avoidance of negative information reverses when effortful cognitive control processes are ineffective (e.g., during divided attention). In line with this explanation, older adults seem to experience no age-related advantages in emotional experience when they cannot employ or are ineffective in avoiding negative situations and events (Charles, 2011). Similar processes might also account for the current findings. However, it seems rather unparsimonious to assume different processes in younger and older adults in interpreting a lack of age-related differences in their behavior (Carstensen & Freund, 1994). Instead, these findings call for further theoretical elaboration resulting in testable hypotheses that specify under which conditions the positivity effect occurs (for a similar conclusion, see Isaacowitz & Blanchard-Fields, 2012).

Regarding estimates of happy faces, the results did not support the hypothesis that younger adults overestimate happy faces based on younger adults' greater motivation to approach new social relationships. In Study 1, younger adults did not overestimate happy faces. In Study 2, younger adults overestimated happy faces but they did not significantly differ in their estimates from older adults. As pointed out above, one explanation of this finding might be the dominance of negative information (Rozin & Royzman, 2001). However, this explanation cannot explain why younger and older adults did not differ in their estimates of happy faces in Study 2, where happy and angry faces were presented separately. An alternative explanation is that younger adults' estimates were more accurate than older adults' estimates (as can be seen from the overall error), leaving less room for the effects of social motivation. At this point in time, these interpretations are only speculative and future studies need to test more directly if people who are particularly motivated to approach new social relationships tend to overestimate the frequency of positive social signals.

Finally, the Valence x Age effect on frequency estimates as found in the present studies might generally reflect more basic mechanisms than those associated with motivation. For example, the greater perceptual similarity between neutral and angry faces as compared with neutral and happy faces might have disproportionately affected older adults, leading to the relatively stronger overestimation of angry faces in this age group than in the group of younger adults. By this account, the overestimation of angry faces would reflect an age-related decline in sensitivity to perceptual differences. The validation study of the FACES database (Ebner et al., 2010) provides some support for this interpretation. In this study, adults of different ages rated the facial expressions of the stimuli. The percentage of correct identifications was high for all facial expressions in all age groups and younger and older adults did not differ in the identification of happy faces. However, older adults were slightly worse than younger adults in identifying angry faces. Note however, that we found no Age x Facial Expression interaction on the overall accuracy of the estimation of different facial expressions in Study 1. In this study, the perceptual difficulty of the presented material was higher than in Study 2 because participants had to distinguish between three facial expressions (angry, happy, neutral). Despite this higher perceptual difficulty, older adults did not significantly differ from younger adults in the accuracy of estimating the frequency of angry faces. This speaks against the interpretation of a general age-related decline in perceptual sensitivity. Future studies are needed to investigate the role of perceptual mechanisms for frequency estimates by manipulating, for instance, the sharpness of the presented pictures. In turn, further studies assessing or manipulating people's motivation would strengthen the motivational interpretation of the current findings.

Age × Presentation Frequency interaction. Finally, the present studies demonstrated that older adults' estimates are dependent on presentation frequency (Study 1), particularly for angry faces (Study 2). This finding is in line with previous research on age-related differences in frequency estimates. For example, Mutter and Goedert (1997) found that the rate of increase in estimated frequency with increasing presentation frequency was lower for older participants. This difference seems to be explained by working-memory deficits in older adults. The higher the working-memory performance, the faster was the rate of increase in frequency estimation over presentation frequency in the study by Mutter and Goedert. When variance associated with differences in working-memory performance was removed, the age differences in the magnitude of frequency estimations were reduces. The present studies add to this knowledge by showing that the magnitude can differ for different stimulus material (e.g., happy and angry faces). However, this was only the case when happy and angry faces were presented separately. More systematic tests of age-related differences in the magnitude of frequency estimations are needed.

Conclusions. Taken together, the current studies are the first step in investigating the expectations of younger and older adults regarding the occurrence of positive and negative social events. The paradigm used in these studies lends itself for further experimental manipulations that will help to understand expectations across adulthood. For instance, a manipulation of future time perspective preceding the assessment of frequency estimates could test if a restricted future time perspective increases the vigilance towards positive or negative faces. Similarly, by manipulating motivational orientation and social goals, their role for frequency estimates that was assumed in the present studies could be tested. With this paradigm, then, we hope to contribute to further understanding of expectations about the occurrence of emotional and social stimuli.

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Footnotes

[1]This procedure resulted in the presentation of 385 happy, 385 angry, and 220 neutral faces. The randomization was conducted as sampling without replacement. This means that each happy and angry face was presented on average 2.25 times and each neutral face was presented 1.29 times. To test for possible habituation effects, we included the actual order of the presentation as an additional predictor in the analysis. We found neither a significant main effect of order nor an Order × Age, Order × Valence, or Order × Age × Valence effect.

[2]This procedure resulted in the presentation of 385 happy, 385 angry, and 770 neutral faces. The randomization was conducted as sampling without replacement. This means that each happy and angry face was presented on average 2.25 times and each neutral face was presented 4.5 times. To test for possible habituation effects, we again included the actual order of the presentation as an additional predictor in the analysis. We found neither a significant main effect of order, nor an Order × Age, Order × Valence, or Order × Age × Valence effect.

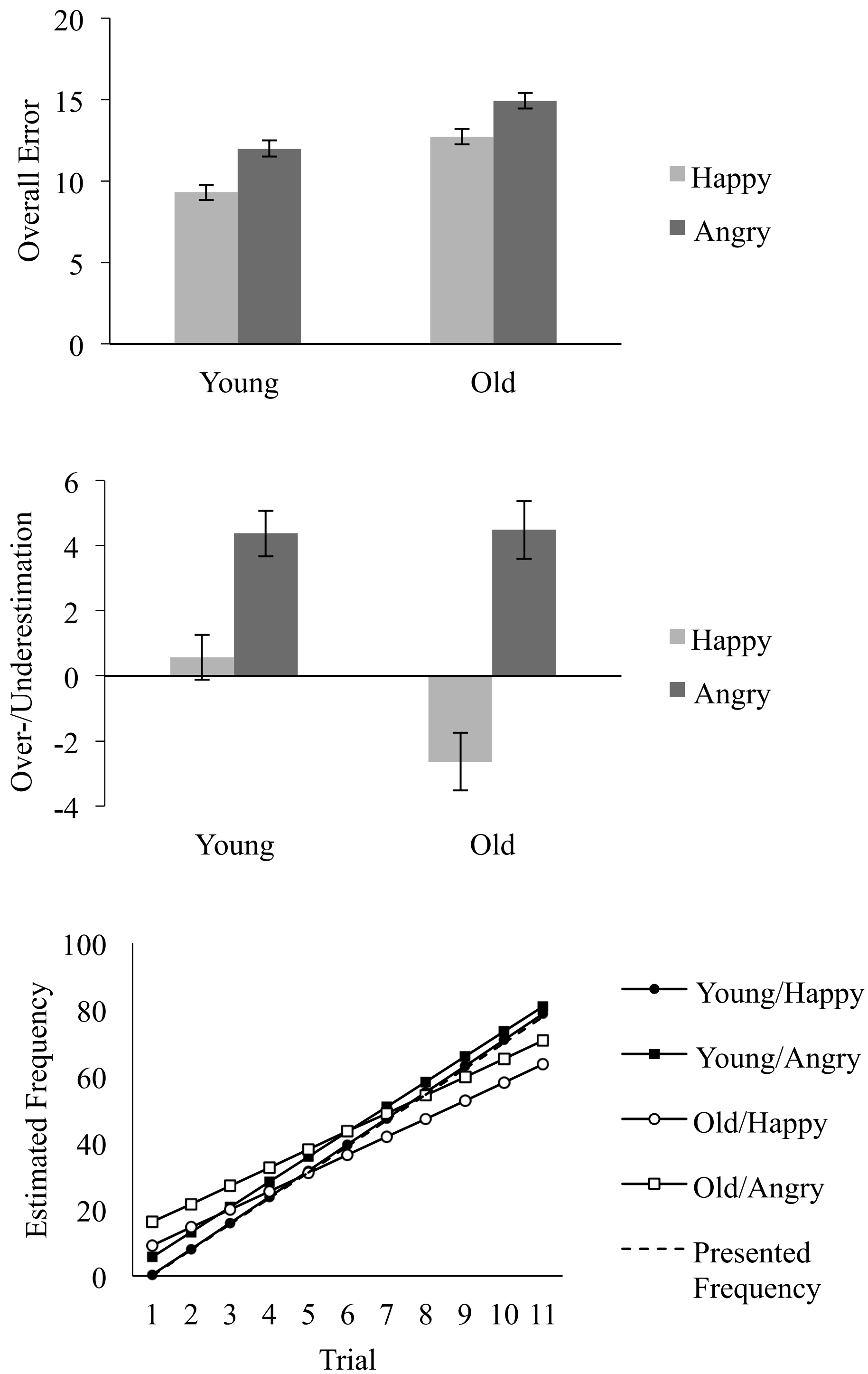

Figure 1. Overall error (upper graph), over- and underestimation (middle graph), and relative accuracy (predicted values, lower graph) as a function of valence of the stimulus and age in Study 1 (n = 91 younger and n = 89 older adults). Values represent percent. Error bars represent standard error of the mean.

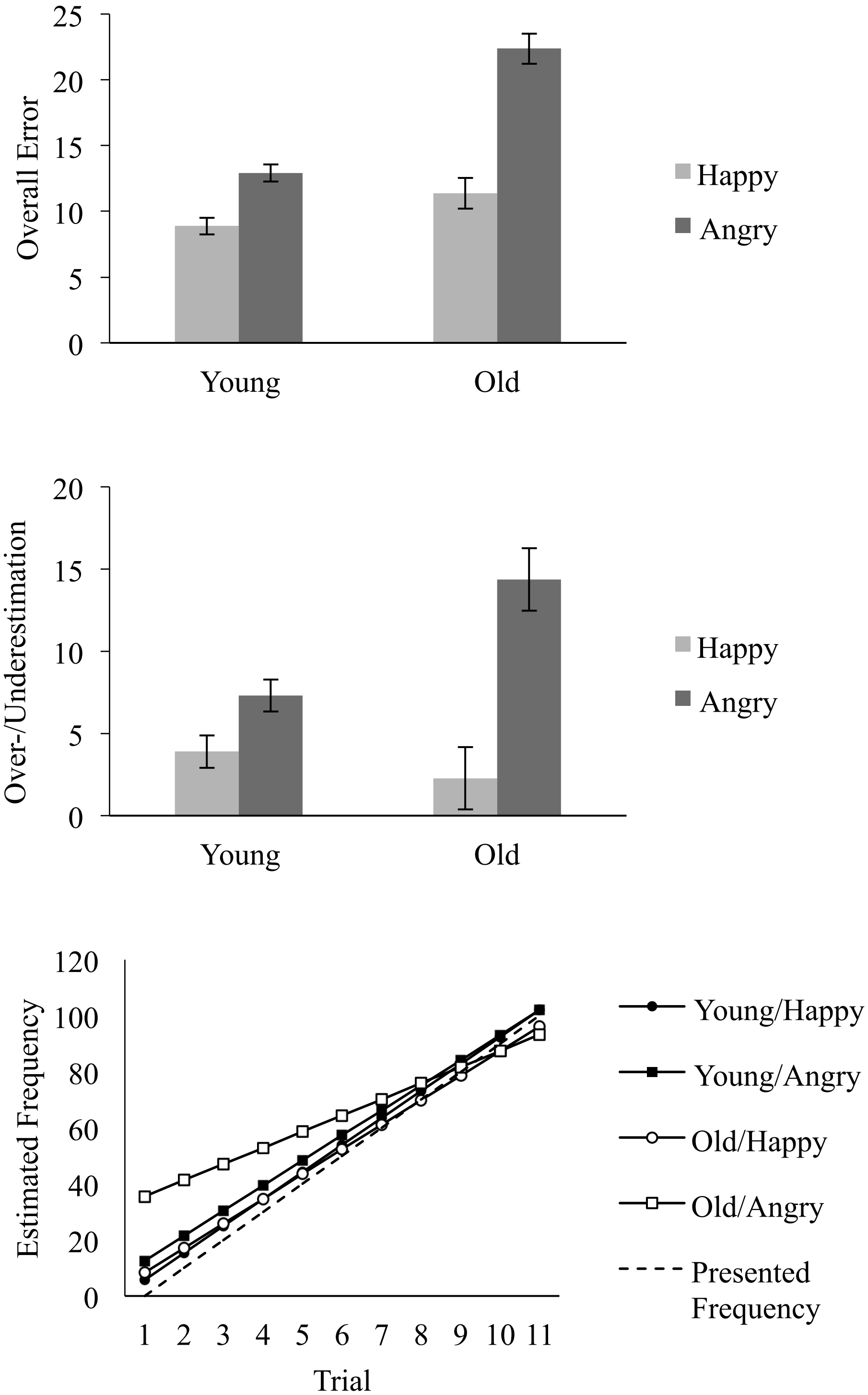

Figure 2. Overall error (upper graph), over- and underestimation (middle graph), and relative accuracy (predicted values, lower graph) as a function of valence of the stimulus and age in Study 2 (n = 50 younger and n = 50 older adults). Values represent percent. Error bars represent standard error of the mean.